Resuscitation 31 (1996) 235–242

Intensive care unit admission following successful cardiopulmonary resuscitation: resource utilization, functional status and long-term survival

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Received 11 July 1995; revision received 20 November 1995; accepted 20 November 1995

Abstract

A retrospective review of consecutive admissions ($n = 285$) to a university hospital intensive care unit (ICU) following cardiopulmonary resuscitation was conducted to determine long-term outcome, length of stay (LOS), and ICU resource consumption. Ninety-four patients (33%) survived to hospital discharge. Hospital survivors had longer ICU LOS than non-survivors (5.1 ± 0.8 vs. 2.8 ± 0.4 days, $P < 0.001$) and longer hospital stays (22.5 ± 3.7 vs. 2.9 ± 1.2 days, $P < 0.001$). Average laboratory and pharmacy costs per admission were greater in hospital survivors than non-survivors. Most patients returned to their pre-arrest homes functionally independent and 58% of hospital survivors were alive 2 years after discharge. It is possible that attempts to appropriately limit therapy in patients with poor prognosis may help direct resources towards patients who will benefit.

Keywords: Intensive care; Cardiopulmonary resuscitation; Cardiac arrest; Cost; Resource consumption; Outcome

1. Introduction

Intensive care units are used to manage patients who achieve spontaneous circulation after either in-hospital or out-of-hospital cardiopulmonary resuscitation (CPR). Little data is available on the costs and length of hospital stay after ICU admission following advanced cardiac life support. Hospital charges of US$95 000 and prolonged hospital and ICU stays have been reported for arrest patients who die in hospital [1]. A recent study found that survivors of in-hospital cardiac arrests spent an average of 17 days in ICU and 14 days on the ward following cardiac arrest [2].

When assessing the success of cardiopulmonary resuscitation it is appropriate to examine the number of hospital and long-term survivors in relation to the number of resuscitation attempts. This principle has been standardized by an international panel in the Utstein criteria for out-of-hospital arrests [3], and has been used by many workers for

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SSDI 0300-9572(95)00926-K

in-hospital arrests [2,4,5]. An alternate approach may be appropriate if hospital resource consumption is examined. Most patients who receive CPR do not respond and never achieve a spontaneous circulation [4,5]. Few post-arrest hospital resources are expended on these patients. The major consumers of hospital resources after CPR are patients who achieve a spontaneous circulation during resuscitation and require ICU admission. As resuscitated patients account for ~14% of our total medical ICU admissions [6] we decided to review admission of successfully resuscitated patients with respect to length of stay, laboratory and drug costs in ICU for hospital survivors and non-survivors, and long-term survival and functional status on discharge for survivors. Major objectives of the review were to determine if differences in cost and resource consumption were related to outcome, and to assess long-term survival after hospital discharge.

2. Materials and methods

2.1. Type of hospital

The Health Sciences Centre is a tertiary care university-affiliated hospital with ~800 beds. It is the designated trauma centre for the city of Winnipeg, and is staffed by interns, residents, fellows, and faculty from the University of Manitoba. There is a 10-bed surgical intensive care unit, a 10-bed medical intensive care unit, and a 6-bed coronary care unit. By hospital policy all post-arrest patients are initially admitted to the medical intensive care unit.

2.2. Arrest team

Resuscitation attempts in all hospital wards except emergency and the operating room are managed by a central arrest team based in the medical intensive care unit. This team includes nursing, respiratory therapy, and physician members. All members are basic life support certified and physicians are certified in advanced cardiac life support. Out-of-hospital resuscitation attempts are managed by ambulance personnel or emergency physicians. The intensive care unit is only notified if these attempts result in return of spontaneous circulation.

2.3. Patient selection

The study population was identified using a computerized database (Critical Care Manager TMS Inc., Chelmsford, Ontario) which contains prospectively collected diagnostic, demographic, Acute Physiology and Chronic Health Evaluation II score (APACHE II) [7], and laboratory, and pharmaceutical administration data for all intensive care unit admissions. The process of data collection has been previously described [6] and approval from the institutional review board for ethical human research for data collection was obtained. During the study period from July 1, 1988 to December 31, 1991 there were 1581 admissions to the unit. Patients admitted to ICU after cardiopulmonary arrest were identified and the hospital charts of these patients reviewed. The study population includes both in-hospital and out-of-hospital arrests as patients resuscitated in the field or emergency room are admitted to ICU if spontaneous circulation returns.

2.4. Arrest definition

For the purposes of the study an arrest was defined by documentation of no palpable spontaneous pulse at the start of CPR, and no effective spontaneous respiration.

2.5. Arrest reporting

As no standard method of reporting in-hospital cardiac arrests has been developed we applied the Utstein guidelines for out-of-hospital arrests to all patients [3]. These guidelines were used to categorize arrest causes as cardiac, non-cardiac or unknown. The initial rhythm (asystole, ventricular fibrillation, ventricular tachycardia, electromechanical dissociation (EMD), and other) was recorded and note was made if the arrest was witnessed or unwitnessed. Only the initial arrest was considered in patients who arrested multiple times during the same hospitalization, however, total ICU time and ICU resource expenditure for subse-

quent admissions were included with the first arrest. Withholding or withdrawal of therapy in the ICU or hospital wards was documented.

2.6. Co-morbidity data

Specific information regarding the following pre-arrest co-morbidity was collected: ischemic heart disease — history of angina, myocardial infarction, congestive heart failure or coronary artery bypass surgery; hypertension — BP over 170/95 or history of antihypertensive use; renal failure — dialysis or creatinine over 250 μmol/l; cancer — documented tumor with or without known metastasis; chronic obstructive pulmonary disease — FEV_1 less than 75% predicted, radiographic evidence of COPD, or home oxygen use; acute liver failure — elevated bilirubin and PT; diabetes — on insulin or oral hypoglycemic.

2.7. Intensive care unit cost data

Laboratory and pharmacy costs are prospectively collected for all ICU admissions. Actual hospital costs per ICU admission are available for 108 individual laboratory or imaging tests and 88 pharmaceuticals.

2.8. Length of stay

ICU length of stay (LOS) is prospectively collected and entered into the database. Hospital LOS was obtained from the chart and long-term survival following hospital discharge was obtained through the death registry of the Vital Statistics Department, Province of Manitoba, Canada. Long-term survival was assessed from hospital discharge and patients were followed until death, or until 2 years had passed without report of their demise. Copies of death certificates were obtained for patients dying during the follow-up period.

2.9. Functional status determination

Functional status was determined retrospectively from the chart for pre-arrest and post-arrest status using the 5 category Pittsburgh modification of the Glasgow Outcome score for cerebral performance categories (CPC) and overall performance categories (OPC) [3,8] (Appendix 1). These categories were retrospectively assigned during chart review. Assignment was initially done by a single individual and then a random sample of 50 charts was independently reviewed by a second individual. No disagreement was noted for the OPC categories between the two individuals. The destination at hospital discharge (home, personal care home, other hospital, nursing home, rehabilitation facility) was collected.

2.10. Statistical analysis

Statistical analysis was done using Statpack (Northwest Analytical Inc., Portland, Oregon). For analysis, patients were categorized as hospital survivors or non-survivors. Nominal data were analyzed using Mann Whitney U-tests as non-normal distributions were encountered. Categorical and ordinal data was analyzed using Chi-square or Fisher's exact test when expected cell counts were less than 5. A significance level of $P < 0.05$ was used. All data with ranges are mean ± S.E.M. All cost data are in 1994 Canadian dollars.

3. Results

3.1. Demographic and survival data

Initially 341 consecutive post-arrest admissions to ICU were identified. Upon chart review 56 patients were excluded as they were not pulseless. Of the remaining 285 admissions there were 94 (33%) who survived to hospital discharge. Arrest characteristics and demographic data for hospital survivors and non-survivors are shown in Table 1. There were statistically significant differences ($P < 0.0001$) in APACHE II scores between survivors (22.5 ± 0.8) and non-survivors (34.4 ± 0.6). ICU admission followed out-of-hospital arrests in 85 patients (30%), and the remaining 200 admissions occurred after in-hospital arrests (70%). Site of arrest was not significantly different in survivors and non-survivors. In this population of resuscitated patients admitted to ICU there were no differences in the percentage of witnessed

Table 1
Demographic and arrest characteristics for survivors and non-survivors

	Survivors	Non-survivors	P value
Number	94	191	
Mean age (years)	62.2 ± 1.8	64.1 ± 1.2	NS
Age range (years)	17–84	18–91	
Male:Female	63:31	113:78	NS
Witnessed arrest	83 (88%)	161 (84%)	NS
Mean APACHE II score	22.5 ± 0.8	34.4 ± 0.6	<0.0001
In-hospital arrest	62 (66%)	138 (72%)	NS
Out-of-hospital arrest	32 (34%)	53 (28%)	NS
V fib/V tach	52 (55%)	59 (31%)	NS
EMD/asystole	42 (45%)	132 (69%)	<0.0001

APACHE, Acute Physiology and Chronic Health Evaluation; V fib, ventricular fibrillation; EMD, electromechanical dissociation; V tach, ventricular tachycardia.

arrests between survivors and non-survivors. Using the Utstein criteria arrests were due to primarily cardiac causes in 57 survivors (60%) and 93 non-survivors (49%). Non-cardiac causes were noted in 27 of the survivors (29%) and 87 of the non-survivors (45%). Arrest cause was unknown in 10 survivors (11%) and 11 non-survivors (6%). A significantly better survival was noted for primary cardiac arrests ($P < 0.01$ vs. non-cardiac causes).

Asystole and EMD were associated with poor survival ($P < 0.001$) although 42 individuals with these initial rhythms survived hospitalization (Table 1). Patients arresting in an ICU had a lower survival than those arresting elsewhere in the hospital (12% vs. 63%, $P < 0.004$).

Table 2 describes the underlying medical problems in the study population. The most frequent problems encountered were ischemic heart disease and hypertension. Two of the 21 patients with metastatic cancer survived to hospital discharge, and 10 of the 26 renal dialysis patients survived hospitalization.

Therapy was withheld or withdrawn in ICU in 124 (65%) of the 191 non-survivors. Forty-one patients with severe neurologic dysfunction (CPC 4) were transferred to the ward following institution of comfort care. No patient who had therapy withheld or withdrawn survived hospitalization.

3.2. Functional status

The pre-arrest functional status of the study

Table 2
Pre arrest co-morbidity characteristics for survivors and non-survivors

	Survivors	Non-survivors	Total
Ischemic heart disease	49 (37%)	82 (63%)	131
Hypertension	34 (33%)	70 (67%)	104
Diabetes mellitus	19 (30%)	45 (70%)	64
COPD	17 (27%)	47 (73%)	64
Cancer — non-metastatic	5 (19%)	21 (81%)	26
Cancer — metastatic	2 (10%)	19 (90%)	21
Acute liver failure	0 (0%)	15 (100%)	15
CRF — no dialysis	10 (38%)	16 (62%)	26
CRF — dialysis	19 (46%)	22 (54%)	41

CRF, chronic renal failure; COPD, chronic obstructive pulmonary disease.

Table 3
Pre-arrest and discharge overall performance category (OPC) for cardiac arrest patients admitted to ICU

Pre-arrest OPC	Functional status at hospital discharge				
	OPC I	OPC II	OPC III	OPC IV	OPC V
OPC I	21	11	8	3	44
OPC II	0	30	11	0	71
OPC III	0	0	10*	0	76
OPC IV	0	0	0	0	0

OPC I, normal; OPC II, mild to moderate disability but functionally independent; OPC III, severe disability and functionally dependent; OPC IV, vegetative state; OPC V, dead.
*$P < 0.0001$ compared to OPC 1 and 2 pre-arrest.

population was equally distributed between OPC 1(87), 2(112), and 3(86) (Table 3). No patients who were OPC 4 pre-arrest were admitted to ICU. Table 3 indicates that 50% of the OPC 1 admissions survived to hospital discharge and that the majority (75%) were functionally independent (OPC 1 or 2). Only 37% of the 112 OPC 2 pre-arrest admissions survived to hospital discharge, however Table 3 reveals that 71% of these survivors were OPC 2 when discharged. Only 10 of 86 admissions (12%) who were OPC 3 before arrest survived to hospital discharge and none were functionally independent.

3.3. Discharge destination

Seventy patients returned home, 17 patients were transferred to peripheral hospitals, 3 were discharged to long-term rehabilitation facilities, and 4 were discharged to chronic care facilities.

3.4. Long-term survival data

Follow-up data were obtained for 2 years following hospital discharge for 92 of the 94 hospital survivors. The 2 patients lost to follow-up were from out of province. Twenty-five individuals expired within 1 year of hospital discharge. The majority (88%) of these died within 6 months of hospital discharge. Sixty-seven individuals survived more than 1 year after hospital discharge and 53 (58%) remained alive after 2 years. Cardiac conditions accounted for most deaths (64%) during the 2 year follow-up. Most patients surviving beyond 2 years (77%) were functionally independent at the time of hospital discharge (OPC 1 or 2).

3.5. Resource consumption data

Survivors stayed in the ICU longer than non-survivors (mean 5.1 ± 0.8 days vs. 2.8 ± 0.4 days, $P < 0.001$; median 2.9 days vs. 1.0 day; range 0.2–48 days for survivors, 0.01–67 days for non-survivors). Survivors averaged longer ward stays post-arrest than non-survivors (mean 22.5 ± 3.7 days vs. 2.9 ± 1.2 days, $P < 0.001$; range 0–285 days vs. 0–188 days). A total of 2589 hospital days were expended in caring for the 94 patients who survived hospitalization vs. 1076 hospital days for non-survivors. Overall 27% of the total hospital days for the entire study population were spent in the ICU.

The mean and median laboratory and pharmacy costs in ICU per admission were higher in survivors than in non-survivors (mean \$766 ± \$120 vs. \$539 ± \$59; $P < 0.01$; median \$416 vs. \$254). The range of laboratory and pharmacy costs in ICU was \$72 to \$8785 in survivors, and \$0 to \$6726 in non-survivors. Non-survivors had higher mean ($P < 0.01$) and median daily costs in ICU (mean \$175 ± \$12; median \$143) than survivors (mean \$145 ± \$7; median \$140).

4. Discussion

Our data show that survival has significant effects on hospital resource consumption after ICU admission following cardiac arrest. Length of stay

and cost are greater in hospital survivors than non-survivors. One third of the study population left hospital, most returning home with independent function (OPC 1 or 2). Over 70% of the discharged patients remained alive 1 year after discharge.

We must emphasize that only patients who responded to resuscitation and developed a spontaneous circulation were included in this study. Earlier studies report that ~40% of resuscitation attempts succeed and result in ICU admission [4,5]. Our 285 post-arrest ICU admissions probably represent over 700 resuscitation attempts and this should be remembered when making comparisons to previous studies. Patient selection also accounts for the apparent good outcome in admissions whose initial rhythm was asystole/EMD. Many of the patients with this initial rhythm never achieved spontaneous circulation when resuscitation was attempted and were not admitted to ICU.

The population admitted to ICU after cardiac arrest was selected as patients who fail to develop a spontaneous circulation do not subsequently consume many hospital resources. Arrest teams must be available and staffed, so are a fixed cost. Resuscitation drugs and equipment are relatively inexpensive and must be stocked and maintained even if unused. Most hospital resources will be consumed by the population who respond to initial resuscitation attempts and require ICU admission, and therefore this group is appropriate as a denominator when assessing resource consumption.

Both in-hospital and out-of-hospital arrests were included in our review as the unit accepts admissions from both locations. This may limit some comparisons regarding outcome as previous studies concentrate on either in-hospital or out-of-hospital arrests [4,5,9–14]. Since our primary focus was hospital resource consumption and outcome after ICU admission we believe it is appropriate to consider all arrest admissions to ICU regardless of location of the initial arrest. Most of the in-hospital arrests were on the general wards of the hospital. We did not have a large population who arrested in high care areas.

Despite including arrests from both locations our outcome results are very similar to previous reports. We found 31% survival after ICU admission following in-hospital arrest. Hospital survival for patients admitted to ICU after in-hospital cardiopulmonary resuscitation has ranged from 21–46% [2,4,5,9–12]. In this study, out-of-hospital arrest survival was 38%. In other studies, hospital survival for ICU admissions after out-of-hospital resuscitation has been 32% [14] to 61% [13].

Average post-resuscitation hospital lengths of stay for survivors have ranged from 17–32 days [2,5,9,14–17]. Jakobsson et al. reported that 15% of the total hospital days for survivors were spent in an ICU setting and that this resulted in 53% of the total costs of hospitalization [14]. We found that 18% of the total hospital days for our survivors were spent in the ICU.

Vrtis reported mean hospital stays of 9.9 days for patients who survived 24 h after resuscitation but subsequently died without leaving hospital [15]. Berger and Kelly recently reported data from an American hospital where non-survivors averaged 16 hospital days (9.8 ICU days) and survivors averaged 31 hospital days (17 ICU days) [2]. In this series patients who survived more than 6 days but died in hospital had average ICU stays of 24 days. We found that non-survivors averaged 5.7 days in hospital after arrest (2.8 days in ICU and 2.9 days on the wards), while survivors averaged 27.6 days in hospital (5.1 ICU and 22.5 ward). Scandinavian studies have found similar average ICU lengths of stay [14–18]. As our overall outcomes are similar to those reported in the literature it is possible that institutional and practice differences may account for the short hospital stays for our non-surviving patients.

These differences could be important if attempts are made to develop models to predict costs in arrest patients. A recent model of the costs of cardiopulmonary resuscitation assumes that non-survivors spend 66% of their hospital stay in the ICU and 33% on the ward, while survivors spend 50% of their stay in ICU and 50% in general medical wards [17]. We found that survivors spent less than 20% of their hospitalization in ICU, and non-survivors spent 49% of their hospitalization in ICU. Average hospital admission was not prolonged in non-surviving patients. The model would not be predictive of costs in our institution

where patients who do not survive hospital have short ICU and hospital stays, and surviving patients spend most of their hospital stay outside of ICU.

We report actual hospital costs rather than charges for pharmaceutical administration and laboratory testing in ICU [19]. Our reported costs do not include physician and nursing labour, equipment, or physical plant costs. Laboratory and pharmaceutical costs account for ~ 15% of the total costs of intensive care in our hospital. Our findings indicate that non-survivors consume as many or more pharmacy and laboratory resources per ICU day as survivors, however their ICU admissions are significantly shorter.

Specific pre-arrest factors including age have been examined to predict the outcome of CPR [4,5,9,11,20–22]. Unfortunately these specific diagnosis-based factors are not always accurate. Intra-arrest characteristics (witnessed/unwitnessed; initial rhythm) are often more predictive of outcome [4]. The inaccuracy of pre-arrest predictors makes intra-arrest factors and post-arrest status more attractive for prognostication and decisions regarding ongoing aggressive support, assuming that one is willing to appropriately limit therapy in patients who have a dismal prognosis for neurologic recovery.

Withdrawing or limiting therapy when the prognosis is dismal or disease pathology irreversible is appropriate medical practice. Most deaths in this study occurred after withholding or withdrawal of therapy in the ICU. The most common indication for limiting therapy was clinical assessment of severe and irreversible neurologic dysfunction due to ischemic, anoxic cortical injury [23–25]. This may explain our short ICU and ward stays for patients who do not survive hospitalization.

Resource consumption considerations should never be the motivation for decisions to withdraw or withhold therapy in an individual. Our data suggests that patients admitted to ICU after resuscitation from cardiac arrest have significant long-term survival unless their pre-arrest functional status was poor or the characteristics of the event suggest a severe anoxic neurologic insult. In our institution surviving patients had prolonged average hospital stays, and non-surviving patients had significantly shorter hospital stays. We believe that early identification of poor prognosis patients allows appropriate medical and ethical decisions to be made regarding ongoing aggressive support. We speculate that this practice may result in a more appropriate focusing of resources toward patients who will most likely benefit.

Appendix I (adapted from [3])

Glasgow-Pittsburgh cerebral performance and overall performance categories

Cerebral performance categories

CPC 1: Good cerebral performance. Conscious. Alert, able to work and lead a normal life. May have minor psychological or neurological deficits (mild dysphasia, non-incapacitating hemiparesis, or minor cranial nerve abnormalities).

CPC 2: Moderate cerebral disability. Conscious. Sufficient cerebral function for part-time work in sheltered environment or independent activities of daily life (dressing, travelling by public transportation and preparing food). May have hemiplegia, seizures, ataxia, dysarthria, or permanent memory or mental changes.

CPC 3: Severe cerebral disability. Conscious. Dependent on others for daily support because of impaired brain function (in an institution or at home with exceptional family effort). At least abnormalities from ambulatory with severe memory, paralytic and able to communicate only with eyes, as in the locked-in syndrome.

CPC 4: Coma, vegetative state. Not conscious. Unaware of surroundings, no cognition. No verbal or psychological interactions with environment.

CPC 5: Death, certified brain dead or dead by traditional criteria.

Overall performance categories

OPC 1: Good overall performance. Healthy, alert, capable of normal life. Good cerebral performance (CPC 1) plus no or only mild functional disability from non-cerebral organ system abnormalities.

OPC 2: Moderate overall disability. Conscious. Moderate cerebral disability alone (CPC 2) or moderate disability from non-cerebral system

dysfunction alone or both. Performs independent activities of daily life (dressing, travelling and food preparation). May be able to work part-time in sheltered environment but disabled for competitive work.

OPC 3: Severe overall disability. Conscious. Severe cerebral disability alone (CPC 3) or severe disability from non-cerebral organ system dysfunction alone or both. Dependent on others for daily support.

OPC 4: Same as CPC 4.

OPC 5: Same as CPC 5.

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